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NITRIFICATION AND DENITRIFICATION OF PARTIALLY TREATED LANDFILL LEACHATE

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By

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia in Fulfilment of the Requirements for the Degree of Master of Science

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

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Chairman : Professor Mohd. Ali Hassan, Ph.D.

Faculty : Food Science and Biotechnology

In this study, biological removal of ammonia, nitrite and nitrate nitrogen of partially treated landfill leachate (PTLL) was conducted by nitrification and denitrification processes. The experiments were conducted by batch treatment using 16L stirred tank reactor in which 8 L of PTLL was treated with 0%, 1%, 5% and 10% (v/v) of centrifuged landfill leachate sludge and the pH was adjusted to 7 at every 12 hour interval. The treatment systems were kept above 80% saturated with oxygen (0.06-0.19 vvm).

It was found that the treatment with 10% centrifuged landfill leachate sludge was sufficient to reduce 93% and 63% of the PTLL's ammonia and nitrite, respectively, under aerobic condition. It was also observed that the level of nitrate can be reduced by 56% by biological means from the PTLL's original concentration of 13,500 ppm during nitrification process. However, subsequent denitrification was not possible due to foaming which occurred during the nitrification treatment with 10% centrifuged

landfill leachate sludge. Large loss of biomass from the system was experienced, even when the flowrate of air supplied was reduced to a very low level at 0.06 vvm. Furthermore, the impeller located at the upper part of the reactor's shaft was unable to break the large amount of foam formed.

As an alternative to prevent foaming, further experiments were carried out in a 6L reactor with the use of 4L synthetic media of (a) defined media with controlled pH between 7.5 and 8.5; (b) model leachate (without organic nitrogen) with (i) pH adjusted to 7 every 12 hours (ii) controlled pH between 7.5 and 8.5; and (c) model leachate (with organic nitrogen and pH controlled between 7.5 and 8.5. These media consisting of ammonia, nitrite and nitrate concentrations of 1000 ppm, 1500 ppm and 3000 ppm, respectively, were treated with 10% of centrifuged landfill leachate sludge for complete nitrification and denitrification processes and to isolate the microbes involved. The saturated oxygen was kept above 80% (0.02 vvm) throughout the treatments.

Complete nitrification and denitrification were achieved at 120 and 168 hours, when defined media and model leachate (without organic nitrogen) were used respectively, under controlled pH between 7.5 and 8.5. The cell population of both treatments was found to increase from 10^8 to 10^{10} cell/ml and 10^9 to 10^{10} cell/ml respectively, at the end of denitrification process, under C/N ratio of 0.4 in which acetic acid was used as carbon source.

Several strains were isolated from nitrification and denitrification processes. They were strains WNZ 1, WNZ 2 and WNZ 3 (ammonia oxidizers) which were unable to be identified by Biolog Identification System, *Acinetobacter calcoaceticus* and *Acidovorax konjaci* (nitrite oxidizers) and *Pseudomonas aeruginosa* 1, *Pseudomonas aeruginosa* 2 and *Pseudomonas aeruginosa* 3 (nitrate oxidizers).

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk Ijazah Master Sains

NITRIFIKASI DAN DINITRIFIKASI LELEHAN SISA PEPEJAL SEPARA RAWATAN

Oleh

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Kajian penyahan nitrogen amonia,nitrit dan nitrat nitrogen dari lelehan sisa pepejal separa rawatan secara biologi dilakukan melalui proses-proses nitrifikasi dan denitrifikasi. Eksperimen dilakukan secara rawatan 'batch' dengan menggunakan reaktor tangki pengadukan 16 L dimana lelehan sisa pepejal separa rawatan dirawat bersama 0%, 1%, 5% dan 10% (v/v) enapcemar lelehan sisa pepejal yang diempar dan pH di laraskan kepada 7 pada setiap 12 jam. Ketepuan oksigen di dalam system-sistem rawatan ini di kawal melebihi paras 80 % (0.06-0.19 vvm).

Didapati, rawatan bersama10% enapcemar lelehan sisa pepejal yang diempar adalah memadai untuk menurunkan 93% dan 63% daripada kepekatan ammonia dan nitrit awalan lelehan sisa pepejal separa rawatan iaitu 400 dan 2000 ppm, setiap satunya di bawah keadaan arobik. Didapati juga bahawa paras nitrat dapat dikurangkan sebanyak 56% daripada kepekatan asal lelehan sisa pepejal separa rawatan iaitu 13,500 ppm pada proses nitrifikasi. Walaubagaimanapun, proses dinitrifikasi seterusnya tidak

dapat dijalankan kerana berlakunya pembuihan semasa rawatan bersama 10% enapcemar lelehan sisa pepejal yang diempar yang menyebabkan kehilangan banyak biomas di dalam system walaupun kepekatan oksigen yang dibekalkan telah diturunkan kepada 0.06 vvm. Pengaduk yang berada di bahagian atas bioreaktor tidak dapat memecahkan buih-buih yang terbentuk.

Sebagai altenatif, eksperimen selanjutnya dijalankan dengan penggunaan media sintetik seperti (1) media tetap dengan kawalan pH diantara 7.5- dan 8.5; (2) model lelehan sisa pepejal (tanpa nitrogen organik) dengan (i) pelarasan pH kepada 7 pada setiap 12 jam (ii) kawalan pH di antara 7.5 dan 8.5; dan (c) model lelehan sisa pepejal (dengan nitrogen organic) dengan kawalan pH di antara 7.5 dan 8.5. Media-media ini mengandungi kepekatan-kepekatan ammonia nitrit dan nitrat pada 1000 ppm, 1500 ppm dan 3000 ppm, setiap satunya dirawat bersama 10% enapcemar sisa pepejal yang diempar untuk pemerhatian proses-proses nitrifikasi dan dinitrifikasi yang lengkap dan untuk memencilkan mikrob-mikrob yang terlibat. Kepekatan oksigen dikekalkan melebihi paras 80% (0.02 vvm) sepanjang rawatan di jalankan.

Nitrifikasi dan dinitrifikasi yang dicapai adalah pada 120 dan 168 jam apabila media tetap dan media model lelehan sisa pepejal (tanpa nitrogen organic) digunakan, setiap satunya di bawah kawalan pH diantara 7.5 dan 8.5. Populasi sel untuk kedua-dua rawatan didapati meningkat dari 10^8 kepada10^{10} sel/ml dan 10^9 kepada 10^{10} sel/ml, setiap satunya pada akhir proses denitrifikasi dengan nisbah C/N 0.4 dimana asid asetik digunakan sebakai punca karbon.

Beberapa strain dapat dipencilkan dari proses-proses nitrifikasi dan dinitrifikasi. Diantaranya ialah strain WNZ 1, WNZ 2 dan WNZ 3 (pengoksida-pengoksida ammonia) yang mana tidak dapat dikenalpasti oleh SIstem Pengenalpastian Biolog, *Acinetobacter calcoaceticus* dan *Acidovorax konjaci* (pengoksida-pengoksida nitrit) dan *Pseudomonas aeruginosa* 1, *Pseudomonas aeruginosa* 2 dan *Pseudomonas aeruginosa* 3 (pengoksida-pengoksida nitrat).

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This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement of the degree of Master of Science. The members of the Supervisory Committee are as follows:

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DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been dully acknowledge. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

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Date: 23/8/04

I certify that an Examination Committee met on 9th April 2004 to conduct the final examination of Manisya Zauri Binti Abdul Wahid on her Master of Science thesis entitled "Nitrification and Denitrification of Partially Treated Landfill Leachate" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are follows:

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v/v	Volume per volume
C/N ratio	Carbon to nitrogen ratio of medium ppm
µmax	Maximum or initial specific growth rate (h^{-1})
BOD	Biological oxygen demand
COD	Chemical oxygen demand
rpm	Rotation per minute
TKN	Total kjedahl nitrogen
TS	Total solids
SS	Suspended solids
VSS	Volatile suspended solids
SBR	Sequencing batch reactor
ppm	Parts per million
mmol	Millimol
SEM	Scanning electron microscopy
TEM	Transmission electron microscopy
µm	Micrometer
O.D	Optical density
M	Molarity